



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 9.5.5 EMERGENCY DIESEL ENGINE COOLING WATER SYSTEM

REVIEW RESPONSIBILITIES

Primary - Power Systems Branch (PSB)

Secondary - None

I. AREAS OF REVIEW

The emergency diesel engine cooling water system (EDECWS) provides cooling water to the station emergency diesel engines and is reviewed to assure conformance with General Design Criteria 2, 4, 5, 17, 44, 45, and 46. The PSB review includes those portions of the EDECWS that receive heat from components essential for proper operation of the diesel engines and that are housed within their respective diesel engine compartments, and those additional parts of the system that transfer the heat to a heat sink. The system includes all valves, heat exchangers, pumps, and piping up to the engine interface.*

1. The PSB reviews the functional performance characteristics of the EDECWS and the effects on those characteristics of adverse environmental occurrences, abnormal operational requirements, accident conditions, and loss of offsite power.
2. The system is reviewed to determine that malfunction or single failure of a component, or the loss of a cooling source, will not reduce the safety-related functional performance capabilities of the system. The PSB verifies that:
 - a. System components and piping have sufficient physical separation or shielding to protect the system from internally or externally generated missiles and from pipe whip and jet impingement caused by cracks or breaks in high- and moderate-energy piping.
 - b. System components are designed in accordance with the design codes required by the assigned quality group and seismic category classifications.

*As defined by the engine manufacturer.

Rev. 2

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

- c. The system is housed in structures designed to seismic Category I requirements.
 - d. Failures of nonseismic Category I structures and components would not affect the safety-related functions of the EDECWS.
3. The PSB reviews the design of the EDECWS with respect to the following:
- a. Functional capability during periods of abnormally high water levels (the probable maximum flood).
 - b. Capability to detect and control system leakage, including isolating portions of the system in the event of excessive leakage or component malfunction.
 - c. Measures to preclude long-term corrosion and organic fouling that would degrade system cooling performance, and the compatibility of any corrosion inhibitors or antifreeze compounds used with the materials of the system.
 - d. The capacity of the EDECWS with regard to the manufacturer's recommended engine temperature differentials under adverse operating conditions.
 - e. Provision of proper instruments and testing systems to permit operational testing of the system.
 - f. Provisions to assure that normal protective interlocks do not preclude engine operation during emergency conditions.
4. The PSB will determine the adequacy of design installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper operation of the system, including interlocks.

In the review of the emergency diesel engine cooling water system, the PSB will coordinate other branches evaluations that interface with the overall review of the system as follows: The Structural Engineering Branch (SEB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of the Category I facility structures housing the system and supporting systems to withstand the effects of natural phenomena such as a safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. The Mechanical Engineering Branch (MEB) determines that components, piping, and structures are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The MEB also determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The Materials Engineering Branch verifies, upon request of PSB, the compatibility of the materials of construction with service conditions. The Auxiliary Systems Branch (ASB) determines that the EDECWS is in accordance with Branch Technical Positions ASB 3-1 and MEB 3-1 for cracks and breaks in high-energy and moderate-energy piping systems outside containment as part of its primary review responsibility for SRP Section 3.6.1. The Procedures and Test Review Branch determines the acceptability of the preoperational and start-up tests as part of its primary review responsibility for SRP Section 14.0.

The reviews for fire protection, technical specifications and quality assurance are coordinated and performed by the Chemical Engineering Branch, Licensing Guidance Branch, and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively.

For those areas of review identified above as being part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branches.

II. ACCEPTANCE CRITERIA

Acceptability of the emergency diesel engine cooling system design, as described in the applicant's safety analysis report (SAR), is based on specific General Design Criteria, regulatory guides, and industry standards. Information obtained from other Federal agencies and reports, military specifications, available technical literature, and operational performance data obtained from similarly designed systems at other plants having satisfactory operational experience will also be utilized in determining EDECWS acceptability.

The EDECWS is acceptable if the integrated system design is in accordance with the following criteria:

1. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3 of the SAR. Acceptance is based on meeting Appendix Position 13 of Regulatory Guide 1.117 as related to the protection of structures, systems, and components important to safety from the effects of tornado missiles.
2. General Design Criterion 4, with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. Acceptance is based on meeting Position C.1 of Regulatory Guide 1.115 as related to the protection of structures, systems, and components important to safety from the effects of turbine missiles.
3. General Design Criterion 5, as related to the capability of shared systems and components important to safety being capable of performing required safety functions.
4. General Design Criterion 17, as related to the capability of the cooling water system to meet independence and redundancy criteria, and General Design Criterion 44, to assure:
 - a. The capability to transfer heat from systems and components to a heat sink under transient or accident conditions.
 - b. Redundancy of components so that under accident conditions the safety function can be performed assuming a single active component failure.
 - c. The capability to isolate components of the system or piping, if required to maintain the system safety function.

To meet the requirements of these regulations the following guidance and positions are used:

- a. Regulatory Guide 1.9, as related to the design of the diesel cooling water system.
 - b. Branch Technical Position ICSB-17 (PSB), as related to engine cooling water protective interlocks during accident conditions.
 - c. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."
 - d. IEEE Standard 387, as related to the design of the diesel engine cooling water system.
 - e. Diesel Engine Manufacturers Association (DEMA) Standard, as related to the design of the engine cooling water system.
5. General Design Criterion 45, as related to design provisions to permit periodic inspection of safety-related components and equipment of the system.
 6. General Design Criterion 46, as related to design provisions to permit appropriate functional testing of safety-related systems or components to assure structural integrity and leaktightness, operability and performance of active components, and the capability of the system to function as intended under accident conditions.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section. For the review of operating license (OL) applications, the procedures are used to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report. The procedures for OL reviews include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the LGB review, as indicated in subsection I of this SRP section.

The design of the diesel engine cooling water system may vary considerably from plant to plant due to the requirements of various diesel engine manufacturers, the number and type of secondary cooling loops used for heat removal, and the number of intermediate cooling loops required to transfer the rejected heat to the ultimate heat sink. Variations in design may also occur due to performances of various architect-engineer firms. Therefore, for the purpose of this SRP section, a typical system is assumed. Any variance in the review procedure, to suit a particular design, will be such that the system review areas in subsection I are covered, and the system will meet the criteria in subsection II of this SRP section.

The primary reviewer will coordinate this review with the other branches' areas of review as stated in subsection I of this SRP section. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

1. The SAR is reviewed to establish that the EDECWS description and related diagrams clearly delineate system operation, individual and total heat removal rates required by components, and the margin in the design heat removal rate capability. The reviewer verifies the following:
 - a. The SEB reviews the seismic design bases and the MEB reviews the quality and seismic classification as indicated in subsection I of this SRP section. The PSB assures that essential portions of the EDECWS including the isolation valves separating essential and non-essential portions are classified Quality Group C and seismic Category I. Components and system descriptions in the SAR that identify mechanical and performance characteristics are reviewed to verify that the above seismic and quality classification have been included and that the P&IDs indicate any points of change at the systems and/or systems components interfaces.
 - b. Failure of a piping interconnection, as shown on system piping and instrumentation diagrams (P&IDs), between subsystems does not cause total degradation of the EDECWS. The results of failure modes and effects analyses are used as a basis of acceptance.
 - c. Provisions have been made to permit inspection of components, as shown on system layout drawings.
 - d. The performance and water chemistry of the EDECWS is in conformance with the engine manufacturer's recommendations.
 - e. The engine "first try" starting reliability has been increased by providing an independent loop for circulating heated water while the engine is in the standby mode.
 - f. A three-way bypass-type thermostatically controlled valve has been provided to control water flow through the jacket water coolers or radiators so that proper coolant temperature is maintained at the engine inlet, as specified by the manufacturer.
 - g. Temperature sensors have been provided to alert the operator when cooling water temperatures exceed the limits recommended by the manufacturer. Protective interlocks in this system are acceptable if the SAR indicates that the interlocks are in conformance with Branch Technical Position ICSB-17 (PSB).
2. The reviewer verifies that the EDECWS can be vented to assure that all spaces are filled with water. Statements in the SAR to the effect that the system design satisfies the above requirement are acceptable.
3. The reviewer verifies that system function will be maintained in the event of adverse environmental phenomena and loss of offsite power. The reviewer evaluates the system, using engineering judgment and the results of failure modes and effects analyses to determine that:
 - a. Failure of nonessential portions of the system or the other systems not designed to seismic Category I requirements and located close to essential portions of the system, or of nonseismic Category I structures that house, support, or are close to essential portions of the EDECWS, will not preclude essential functions. Reference to

SAR sections describing site features and the general arrangement and layout drawings will be necessary, as well as the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR to the effect that the above conditions are met are acceptable.

- b. The essential portions of the system are protected from the effects of floods, hurricanes, tornadoes, and internally and externally generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the SRP sections for Chapter 3 of the SAR. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles, is acceptable.
4. The reviewer verifies that there are no high- or moderate-energy piping systems located close to the EDECWS or that the EDECWS is protected from the effects of postulated breaks in these systems. The means of providing such protection are given in Chapter 3 of the SAR and procedures to review the information presented are given in the SRP sections for the chapter.
5. The descriptive information, P&IDs, onsite emergency power supply drawings, and system analyses are reviewed to assure that essential portions of the system will function following design basis accidents, assuming a concurrent single active component failure. The reviewer evaluates the results of failure modes and effects analyses presented in the SAR to ensure the functioning of required portions of the system.
6. The performance requirements of the diesel engine are reviewed to determine the time available to provide cooling water to the diesels and the other systems that have to operate to assure onsite power capability.
7. The reviewer verifies that the EDECWS and the diesel generator can perform for extended periods when less than full electrical power generation is required without degradation of performance or reliability. A statement to the effect that operating procedures will be provided requiring loading of the engine up to a minimum of 25% of full load for 1 hour after 8 hours of continuous no-load operation or as recommended by the manufacturer will be acceptable.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The emergency diesel engine cooling water system (EDECWS) includes all piping, valves, heat exchangers, and pumps up to the points where the cooling water piping connects to the engine interfaces. The scope of review of the diesel engine cooling water system for the _____ plant included layout drawings, process flow diagrams, piping and instrumentation diagrams, and descriptive information for the system and auxiliary supporting systems that are essential to its operation. The essential portions of the EDECWS that are necessary to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The basis for acceptance of the EDECWS in our review was conformance of the designs, design criteria, and bases to the Commission's regulations as set forth in the General Design Criteria (GDC) of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDC 2, 4, 5, 17, 44, 45, and 46. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," with respect to the ability of structures housing the EDECWS and the system itself to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, and GDC 4, "Environmental and Missile Design Bases," with respect to structures housing the system and the system itself being capable of withstanding the effects of externally and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. The EDECWS is housed in a seismic Category I structure which provides protection from the effects of tornado, tornado missiles, turbine missiles, and floods. This meets the positions of Regulatory Guides 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and 1.117, "Tornado Design Classification," Appendix Position 13.
2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components," with respect to capability of shared systems and components important to safety to perform required safety functions. Each unit of the _____ plant has its own emergency diesel generators whose EDECWS is not shared between the diesel generators.
3. The applicant has met the requirements of GDC 17, "Electric Power Systems," with respect to the capability of the cooling system to meet independence and redundancy criteria, and GDC 44 with respect to the following:
 - a. The capability to transfer heat from systems and components to a heat sink under transient or accident conditions,
 - b. Redundancy of components so that under accident conditions the safety function can be performed assuming a single active component failure, and
 - c. The capability to isolate components of the system or piping, if required to maintain the system safety function.

Each EDECWS is independent and physically separated from the other system serving the redundant diesel generator. A single failure in any one of the two systems will affect only the associated diesel generator. The EDECWS transfers the heat generated by the diesel to the ultimate heat sink via the heat exchangers and the service water system. This meets the position of Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants." The applicant has also met the positions of Branch Technical Position ICSB-17 (PSB), "Diesel Generator Protective Trip Circuit Bypasses," and NUREG/CR-0660,

"Enhancement of Onsite Emergency Diesel Generator Reliability." The applicant has met the requirements of the following industry standards: IEEE Standard 387, "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," and Diesel Engine Manufacturers Association (DEMA) Standard.

4. The applicant has met the requirements of GDC 45 with respect to design provisions to permit periodic inspections of safety-related components and equipment of the system and GDC 46 with respect to design provisions to permit appropriate functional testing of safety-related systems or components to assure structural integrity and leaktightness, operability and performance of active components, and the capability of the system to function as intended under accident conditions. To assure structural integrity and leaktightness, operability and performance of active components, and the capability of the system to function as intended, the diesel engine cooling water system has provisions to permit periodic inspection and functional testing during standby and normal modes of power plant operation.

The staff concludes that the design of the diesel engine cooling water system conforms to all applicable GDCs, positions of the regulatory guides cited, NUREG/CR-0660, staff positions, and industry standards, and is therefore acceptable.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREG.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2; "Design Bases for Protection Against Natural Phenomena."
2. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."
3. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."
4. 10 CFR Part 50, Appendix A, General Design Criterion 17, "Electric Power Systems."
5. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water System."

6. 10 CFR Part 50, Appendix A, General Design Criterion 45, "Inspection of Cooling Water System."
7. 10 CFR Part 50, Appendix A, General Design Criterion 46, "Testing of Cooling Water System."
8. Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants."
9. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."
10. Regulatory Guide 1.29, "Seismic Design Classification."
11. Regulatory Guide 1.68, "Initial Test Programs for Water Cooled Reactor Power Plants."
12. Regulatory Guide 1.115, "Protection Against Low Trajectory Turbine Missiles."
13. Regulatory Guide 1.117, "Tornado Design Classification."
14. Branch Technical Position ASB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to SRP Section 3.6.1.
15. Branch Technical Position MEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," attached to SRP Section 3.6.2.
16. Branch Technical Position ICSB-17 (PSB), "Diesel-Generator Protective Trip Circuit Bypasses," attached to SRP Section 8.3.2, Appendix 8A.
17. Branch Technical Position ASB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants," attached to SRP Section 9.5.1.
18. IEEE Standard 387, "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations."
19. Diesel Engine Manufacturers Association (DEMA) Standard.
20. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."